

TUMBLEWEED: A WIND-PROPELLED SURVEY VEHICLE FOR ASTROBIOLOGY AND PLANETARY SCIENCE. K. R. Kuhlman¹, A. E. Behar¹, J. A. Jones¹, F. Carsey¹, M. Coleman¹, G. Bearman¹, M. Buehler¹, P. J. Boston³, C. P. McKay³, L. Rothschild³, J. Antol⁴, G. A. Hajos⁴, W. C. Kelliher⁴, I. A. Carlsberg⁴, J. P. Keyes⁴, M. Rudisill⁴, R. L. Crawford⁵, ¹Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109 USA, kkuhlman@jpl.nasa.gov, ²New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, NM 87801 USA, ³NASA Ames Research Center, Moffett Field, CA 94035 USA, ⁴NASA Langley Research Center, Hampton, VA 23681-2199 USA, ⁵Environmental Biotechnology Institute, Univ. of Idaho, Moscow, ID 83844-1052, USA

Introduction. Seasonally receding frost at Mars' higher latitudes provides liquid water; transient on the surface and longer-lived below it. Addition of sunlight and evaporitic dust offer possible surficial habitats, albeit only seasonally, although subsurface habitats might support life longer. Surficial habitats might populate a large area, perhaps from 50 degrees to the poles themselves, and this in turn suggests the significant value of a long-range survey for high latitude habitats. Site types particularly suitable to this survey include desert surfaces, duricrusts, pavements, ice surfaces and large flat-bottomed canyons. Such a survey could be readily accomplished with a fleet of Tumbleweeds - - large, inflatable, beach-ball-like vehicles capable of using the readily available wind to traverse the surface with minimal power, while optimizing their capabilities to perform a variety of measurements over relatively large swaths of terrain. Tumbleweeds have been proposed to conduct long-range, randomized surveys of habitability equivalent to conventional coordinate grid sampling. These vehicles will be released to roam for the duration of a season or longer, possibly on the residual martian ice cap.

Proposed Tumbleweed Deployments. Field campaigns in the Atacama Desert, Chile and the McMurdo Dry Valleys, Antarctica will demonstrate this approach on Earth and test the hypothesis: that water indicates habitability and microbial life will correlate with amount of water. Field campaign sites incorporating both snow surfaces and dry desert occur at high latitudes with more accessible hot deserts at mid to low latitudes. The Earth science objectives of these tests are to 1) document the heterogeneity of surface and near-surface habitability in these terrains and 2) measure the extent of biological activity within these habitats.

Instrumentation. The objectives of the proposed field campaigns will be accomplished by 1) outfitting the vehicle with mature instrumentation, 2) following the GPS trail of the Tumbleweed with a chase team equipped with a suite of field instrumentation and 3) analyzing samples collected along the route using a variety of laboratory instruments. The instruments onboard Tumbleweed include the Soil and Ice Conductivity Instrument (SICI), a commercial gas monitor capable of measuring oxygen, ammonia, carbon dioxide and hydrogen sulfide, a tunable diode laser (TDL) detector for water vapor, and a Computed Tomography Imaging Spectrometer (CTIS). These are the first set of instruments selected, but other low-mass, low-power instruments may be considered. The chase suite will include a portable gas chromatograph, ground penetrating radar and X-ray fluorescence (XRF) spectrometer. In-depth laboratory analyses will include direct microbial enumerations and phospholipid fatty acid (PFLA) analyses. Sequencing clone libraries from DNA extracted from the samples and performing phylogenetic analyses on these sequences will characterize the microbial populations. Exoenzyme assays *in situ* will also be performed to measure metabolic activity. Finally, analytical XRF and X-ray diffraction (XRD) will be performed to further characterize the concentrations and phases in which biologically important elements are present.

Acknowledgements. This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration and at the NASA Langley Research Center.